Physics 110
Biological physics

Dr Alaa S Hamid

professor of Physics

Deanship of Educational Services

Qassim university

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Physics 110

* **1st midterm**
* Chapter 1 Kinematics
* Chapter 8 waves
* Chapter 9 sound and Hearing
* Chapter 11 pressure

- 2nd midterm

  Chapter 14 non viscous fluid
- Chapter 15 viscous fluid
- Chapter 22 thermodynamics
- Chapter 29 the nature of light
- Chapter 38 medical imaging

Physics 110
Kinematics

- Units and dimensions
- Prefixes
- vector and scaler quantities

Units and Dimensions

* Basic units	MKS unit	symbol
1. Length	meter	m
2. Mass	kilogram	Kg
3. Time	second	s
4. Illumination	candela	cd
5. Electric current	ampere	A
6. Temperature	kelvin	K
7. Quantity of Substance	mole	mol

* The first three units are called [MKS] unit

Derived units

* Derived units
* Have more than one unit

Area		m^2
Volume		m^3
Speed		ms^{-1}
Velocity		ms^{-1}
Acceleration		ms^{-2}
Gravity		ms^{-2}
Momentum		$kg{\cdot}m.s^{-1}$
Force	(N)	$Kg.m.s^{-2}$
Energy	(J)	$Kg\ m^2\ s^{-2}$
Pressure	(Pa)	$Kg\ m^{-1}\ s^{-2}$

example:
show what is the following units

kg m s^{-2}

1. The force F= mass x gravity = kg x m s^{-2}

kg $(m\ s^{-1})^2$

2. The energy= $\frac{1}{2}$ x mass x $(velocity)^2$ = kg x m^2 s^{-2}

kg x ms^{-2} / m^2

3. The pressure= force / area = kg x ms^{-2}/ m^2

= Kg m^{-1} s^{-2}

kg m s^{-1}

4. The momentum = mass x velocity = kg m s^{-1}

example:
show what is the following units

* Viscosity = force/(velocity x distance)

* Surface tension = force /length

* Refractive index = angle /angle

* Frequency = velocity / length

SI Prefixes

Big prefixes

kilo	k	10^{3}
mega	M	10^{6}
giga	G	10^{9}
tera	T	10^{12}

Little prefixes

pico	p	10^{-12}
nano	n	10^{-9}
micro	μ	10^{-6}
milli	m	10^{-3}
centi	c	10^{-2}

Vector and scalar quantities

Vector - quantity that defined by both magnitude (size) and direction

Scalar - quantity that defined by magnitude only

Vectors:

- Displacement
- Velocity
- Acceleration
- Momentum
- Force

Scalars:

- Distance
- Speed
- Time
- Mass
- Energy

Mass vs. Weight

Mass

- Scalar (no direction)
- Measures the amount of matter in an object

Weight

- Vector (points toward center of Earth)
- Force of gravity on an object

On the moon, your mass does not change, but the magnitude of your weight would be less.

Chapter 1
kinematics

* Is that part of mechanics which is concerned with he description of motion

In this chapter we will study the following topics

* Distance and displacement
* Speed and velocity
* Acceleration
* Average velocity or speed
* Acceleration due to gravity
* Exercises

kinematics

* Kinematics:
* It is that part of mechanics which is concerned with the description of motion.

  * Distance & Displacement
  * Speed & Velocity
  * Acceleration & gravity

Kinematics definitions

* **Position** (*x*)
* where you are located at spacial points

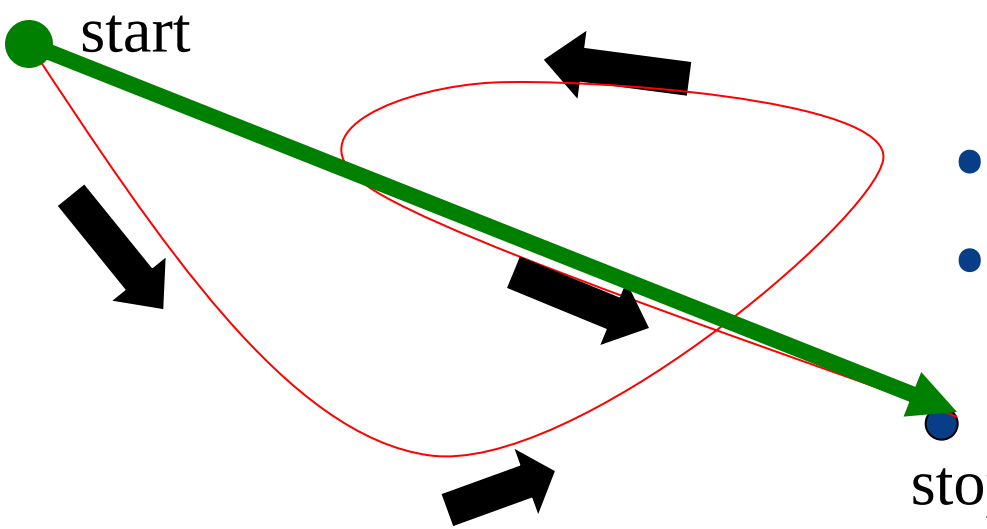
* **Distance** (*d*)
* The distance of path between two points
* Or
* How far you have traveled, regardless of direction

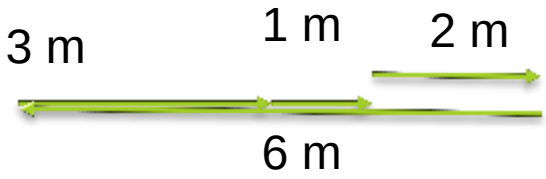
Displacement (Δx)

* The vector equivalent for distance
  * Or
* It specifies the distance and direction of one point relative to another
  * Or
* where you are in relation to where you started

Distance vs. Displacement

* You drive the path, and your odometer goes up by 6 miles (your distance).
* Your displacement is the shorter directed distance from start to stop (green arrow).





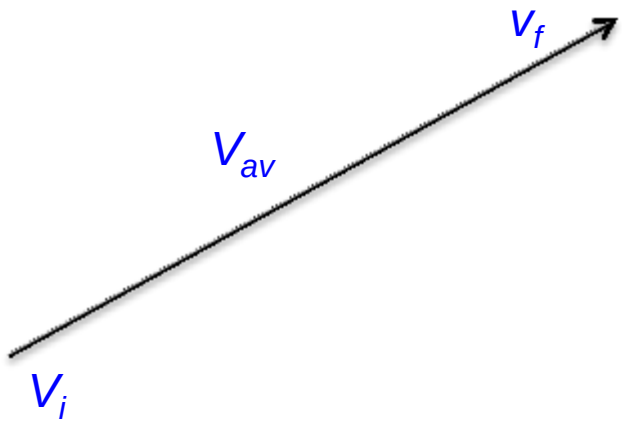
- Distance = 6 m
- Displacement = 0 m

Speed, Velocity, & Acceleration

* **Speed** (v) =v
* How fast you go
* A scaler measure of the rate of motion
* **Velocity** $(\boldsymbol{v}) = \vec{\mathbf{v}}$
* how fast and which way;
the rate at which position changes
* A vector measure of rate of motion
* Units of speed velocity is m/s

Average speed (*v*)

* **distance/time**
* **Total distance /total time**
    * $v_{av} = (v_i + v_f)/2$
* ***Average velocity*** V_{av}
* ***Initial velocity*** V_i
* ***Final velocity*** v_f

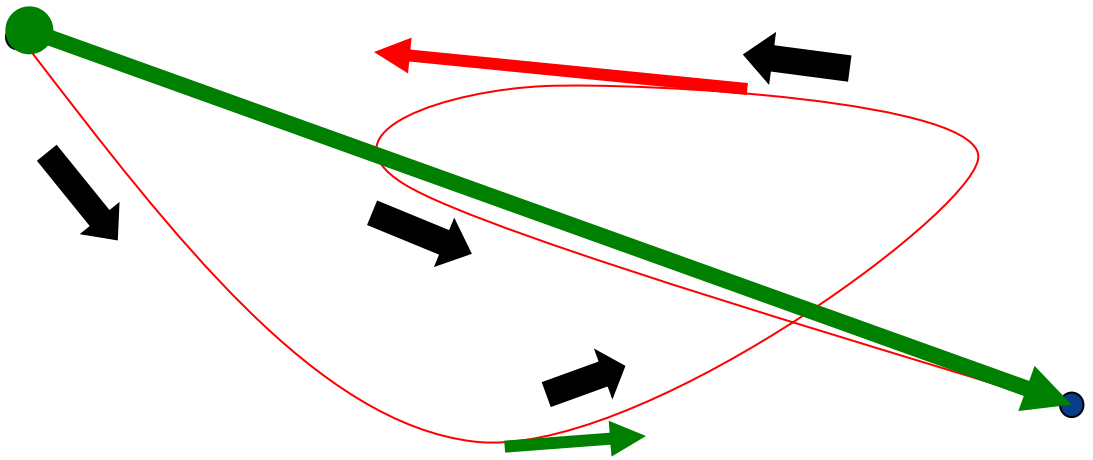


Speed vs. Velocity

* Speed is a scalar
* (how fast something is moving regardless of its direction).
  Ex: v = 20 m/s
* Speed is the magnitude of velocity.
* Velocity is a combination of speed and direction.
* Ex: $\mathbf{v}$ = 20 m/s at 15° south of west
* The symbol for speed is v.
* The symbol for velocity is type written in bold: $\mathbf{v}$ or hand written with an arrow: $\vec{v}$

Speed vs. Velocity

* During your 8 meters trip, which took 2 second., your **speedometer** displays your **instantaneous** speed, which varies throughout the trip.
* Your average speed is= 8/2 = 4 m/s.
* Your average velocity is 4 m/s in a SE direction.
* At any point in time, your velocity vector points tangent to your path.
* The faster you go, the longer your velocity vector.



Acceleration

Acceleration – how fast you speed up, slow down, or change direction; it's the rate at which velocity changes. Two examples:

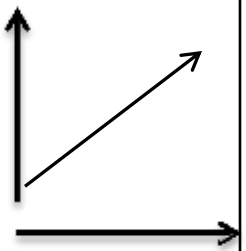
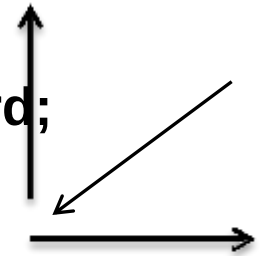
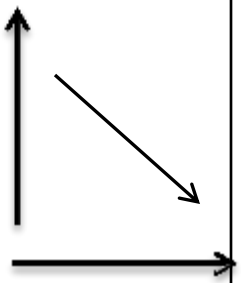
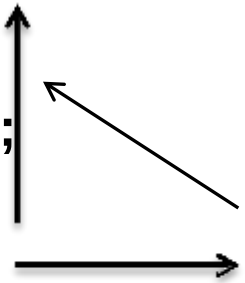
Acceleration = (final velocity – initial velocity)/time

t (s)	*v* (mph)
0	55
1	57
2	59
3	61

t (s)	*v* (m/s)
0	34
1	31
2	28
3	25

$$a = +2 \frac{\text{m/s}}{\text{s}} = +2 \text{ m/s}^2 \qquad a = -3 \frac{\text{m/s}}{\text{s}} = -3 \text{ m/s}^2$$

Velocity & Acceleration Sign Chart

ACCELERATION	VELOCITY +	VELOCITY -
+	Moving forward; Speeding up 	Moving backward; Slowing down 
-	Moving forward; Slowing down 	Moving backward; Speeding up 

Different cases of acceleration

* 1. As the velocity increases the acceleration is +ve
* 2. As the velocity decreases the acceleration is -ve
* 3. If the speed is constant the acceleration = zero
* 4. In the case of the circular motion the acceleration is not equal to zero

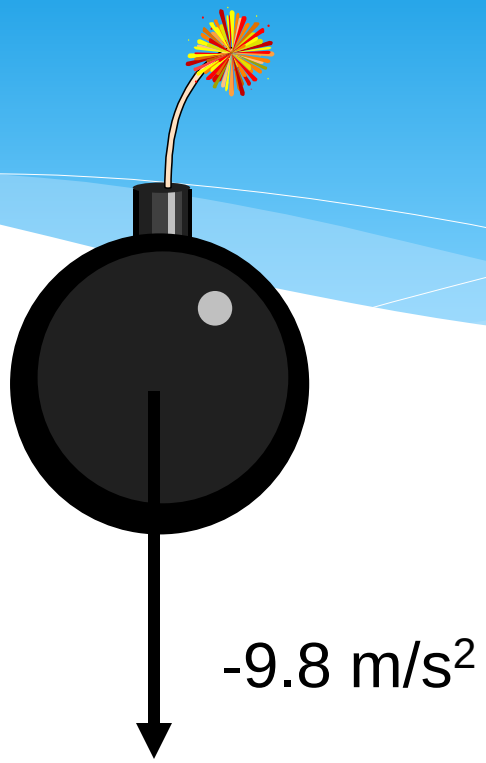
(This is due to the fact that even if the speed is constant but the velocity is not constant)

Acceleration due to Gravity

Near the surface of the Earth, all objects accelerate at the same rate (ignoring air resistance).

$a = -g = -9.8\ m/s^2$

$= -10\ m/s^2$



This acceleration vector is the same on the way up, at the top, and on the way down!

Interpretation: Velocity decreases by 9.8 m/s each second, meaning velocity is becoming less positive or more negative. Less positive means slowing down while going up. More negative means speeding up while going down.

Kinematics Formula Summary

For 1-D motion with *constant* acceleration:

- *Average velocity*
- $\bar{v} = (v_0 + v_f)/2$
- The height
- $\Delta h = v_0 t + \frac{1}{2} a t^2$

(derivations to follow)

Kinematics Derivations

$g = \Delta v / \Delta t$ (by definition)

$\Delta v = g \times \Delta t$

$$t = \sqrt{\frac{2\,h}{g}}$$

1. A ball is dropped from a high tower in 4 seconds. Calculate the height of the tower.

$$h = v_0 t + \frac{1}{2} g t^2$$

$V_0 = 0$

$$h = \frac{1}{2} \times 10 \times 4^2$$

$$= 80 \text{ m}$$

2. A ball is dropped from tower of 20 m height. Calculate the time required to the ball to reach the ground

$$t = \sqrt{\frac{2h}{g}} \quad t = \sqrt{\frac{2 \times 20}{10}}$$

$$t = 2 \text{ s}$$

Exercises 1

A car starts moving at 6 Km from the origin it reaches point 15 Km after 10 min. Calculate the velocity

* Answer
* X_f=15x 1000=15000 m
* X_i= 6x 1000 = 6000 m
* T = 10x60 = 600 s
* $v = \frac{\Delta x}{\Delta t} = \frac{15000-6000}{600} =$ 9 m/s

Exercise 2

A car is moving with velocity 5 m/s it increases its velocity to be 15 m/s in 5 s. calculate the acceleration

* Answer
* $a = \frac{\Delta v}{\Delta t} = \frac{v_f - v_i}{t_f - t_i} = \frac{15-5}{5} = 2\ ms^{-2}$

Exercise 3

A car is moving with velocity 15 m/s it decreases its velocity to be 5m/s in 5 s. calculate the acceleration

Answer

$$a = \frac{\Delta v}{\Delta t} = \frac{v_f - v_i}{t_f - t_i} = \frac{5 - 15}{5} = -2\ ms^{-2}$$

Exercise 4

* If you through a cricket ball straight up at 12 m/s , how high it will go?
* Answer
  * $t = -12/-10 = 1.2\ s$
  * $v = (v_0 + v_f)/2 = 6 m/s$
  * $d = v \times t$
  * $\vec{d} = 6 \times 1.2 = 7.2\ m$ $\rightarrow$

Exercise 5

- How long does it take the above ball to fall to the ground?

Answer

$$t = \sqrt[2]{\frac{2d}{g}} = \sqrt{\frac{2\times -7.2}{-10}} = 1.2 \text{ second}$$

Exercise 6

- What is velocity of the ball in the above example

Answer

$$\Delta v = g.t$$

$$= 10 \times 1.2 = 12 \text{ m/s}$$

Exercise 7

* Of the ball fall from 8.4 m to the ground what is its velocity just before to hit the ground?
  * Answer

$$t = \sqrt[2]{\frac{2d}{g}} = \sqrt{\frac{2\times -8.4}{-10}} = 1.3 \text{ s}$$

$$\Delta v = g.t$$

$$= 10 \times 1.3$$

$$13 \text{ m/s}$$

Kinematics Derivations (cont.)

$$v_f = v_0 + at \quad \Rightarrow \quad t = (v_f - v_0)/a$$

$$\Delta x = v_0 t + \frac{1}{2} a t^2 \quad \Rightarrow$$

$$\Delta x = v_0 [(v_f - v_0)/a] + \frac{1}{2} a [(v_f - v_0)/a]^2$$

$$\Rightarrow \quad v_f^2 - v_0^2 = 2a\Delta x$$

Note that the top equation is solved for t and that expression for t is substituted twice (in red) into the Δx equation. You should work out the algebra to prove the final result on the last line.

MCQ

1. [Kg m^{-1} s^{-2}] is the dimensional formula of

* (A) force (B) coefficient of friction (C) pressure (D) energy

2. The dimensional formula of coefficient of pressure

* (A) Pa (B) N/m (C) Pa.s (D) J

3. The total distance covered in total time taken is termed as

a. instantaneous speed b. average speed

c. uniform speed d. acceleration

4. Velocity is the

a. distance covered per unit time b. displacement covered per unit time

c. time taken per unit distance d. time taken per unit displacement

5. speed is the

a. distance covered per unit time b. displacement covered per unit time

c. time taken per unit distance d. time taken per unit displacement

6. The speed of the truck is 40 ms^{-1}, after 10 seconds its speed decreases to 20 ms^{-1}, its acceleration is

a. -1 ms^{-1} b. -2 ms^{-2} c. -4 ms^{-1} d. -5 ms^{-1}

7. When speed of the object changes, the velocity

a. remains same b. also changes
c. decreases d. increases

8. A car stops and then starts accelerating uniformly at the rate of 3 ms^{-2}. The speed of the car after 20 seconds is

a. 40 ms^{-2} b. 60 ms^{-1} c. 100 ms^{-2} d. 30 ms^{-2}

9 Deceleration is also known as

a. Retardation b. acceleration c. opposite velocity d. inertia

10. Air resistance is a

a. frictional force b. gravitational force
c. backward force d. balanced force

11. The change of distance in a specified direction per unit time is termed as

a. Acceleration b. Velocity c. Speed d. Directional Speed

12. When the speed remains constant, the velocity

a. may change b. remain constant c. must changes
d. slightly increases

13. In symbols the formula of acceleration is

a. $a = v/t$ b. $a = v_f - v_i / t$ c. $a = v_i - v_f / t$ d. $a = v_i / v_f - t$

14. The speed remains constant and the velocity changes when the motion is

a. Linear motion b. circular motion c. constant acceleration

model questions on chapter 1 kinematics

1. The time interval between two events	Elapsed time
2. The length of the path between two special positions	Distance
3. A vector equivalent of distance - It specifies the distance and direction of one point in space relative to another	Displacement
4. A scalar measure of the rate of motion	Speed
5. The change of displacement with respect to time - A vector measure of the rate of motion - It specifies both the magnitude and direction of the rate of motion	Velocity
6. The SI unit of speed (velocity) is	m/s ms^{-1}
7. A measure rate of the velocity - Acceleration is a vector quantity	Acceleration

8. The SI unit of acceleration id	m/s^2 ms^{-2}
9. The following are vector quantity	Displacement Velocity - Acceleration
10. The following are scalar quantity	Distance - Speed Time - energy
11. A car is moving a distance 24 m in 8 seconds. Its velocity is	3 m/s
12. A car is moving with velocity 3 m/s for 8 seconds. The distance that car moves is	24 m
13. Aa car starts moving with velocity 3 m/s. its velocity increases to be 5 m/s in 5 seconds, the acceleration is	(5-3)/5 $0.4\ m/s^2$
14. A car is moving with constant velocity 3m/s for 10 seconds. Its acceleration during this time is	Zero

The end of chapter 1